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MEMORANDUM

From: **Mark Bolinger and Ryan Wiser, Berkeley Lab**
Subject: **Revealed Wind Costs: Analysis of Normalized PPA Cost Data**
Date: **January 31, 2003**

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Analysis of Revealed Wind Project Cost Data

In a memorandum dated May 1, 2002, we summarized the contract terms of 13 recent power purchase agreements that we have collected for wind power projects. In a subsequent memorandum dated May 2, 2002, we provided a quick-and-dirty analysis of the price terms contained in those contracts, as well as prices contained in 9 additional earlier contracts that were summarized by Richard Price of TMS. This memorandum refines our May 2, 2002 analysis in a number of ways:

- We calculate *actual* levelized prices (i.e., over actual contract terms) and add them to Table 1. In our previous memo, we presented only the 25-year levelized price, which is a somewhat artificial normalized price used for comparison purposes only.
- We take each project's commercial operation date into account (for real price calculations only). Projects coming on line in the first 6 months of a year are assumed to have begun commercial operations in that year, while projects coming on line in the last 6 months of a year are assumed to have begun commercial operations in the following year.
- We present prices in both nominal and real (i.e., constant 2001) dollars. The base year 2001 was chosen to match the base year of AEO 2003.
- We used the inflation forecast from AEO 2003 instead of our previous assumption of a flat rate of 3%/year.
- We tested each of the plotted relationships for statistical significance.

Table 1 presents the key terms of these 22 contracts (totaling 1,390 MW, or half of the wind power capacity installed between 1998 and 2001, and one-third of total installed wind capacity in the United States as of the end of 2001). The contracts are sorted by commercial operation date (actual or expected); the first 9 are those summarized by Richard Price of TMS, while the last 13 (starting with Addison) are those summarized in our May 1 memo.

Table 1. Key Contract Terms

Project Name	On-Line Date	Contract Term (Years)	Project Capacity (MW)	Project Capacity Factor	Actual Nominal Levelized Price* ($/MWh)	Actual Real Levelized Price (2001 $/MWh)	25-Year Nominal Levelized Price* ($/MWh)	25-Year Real Levelized Price (2001 $/MWh)
Lake Benton I (MN)	Sep-98	30.0	100.1	37.3%	31.3	26.8	31.5	27.6
Vansycle (OR)	Oct-98	30.0	24.9	34.5%	57.0	49.0	55.7	49.0
Lake Benton II (MN)	May-99	25.0	103.5	37.3%	30.7	26.9	30.7	26.9
Buena Vista (IA)	Jun-99	33.0	9.0	31.4%	48.7	41.2	49.4	43.3
Foote Creek III (WY)	Jun-99	15.0	24.8	40.2%	42.6	39.7	40.5	35.6
Southwest Mesa (TX)	Jun-99	20.0	74.9	40.6%	28.2	25.4	28.3	24.8
Storm Lake II (IA)	Jun-99	20.0	75.0	29.4%	51.7	46.6	50.4	44.1
Storm Lake I (IA)	Jun-99	20.0	112.5	N/A	44.6	40.1	43.7	38.1
Foote Creek IV (WY)	Oct-00	20.0	16.8	41.9%	37.9	32.7	37.4	31.4
Addison (WI)	Dec-00	10.0	29.7	27.4%	58.8	54.3	49.5	41.4
Montfort (WI)	Jul-01	10.0	25.5	23.0%	91.5	82.8	71.6	58.5
Peetz Table (CO)	Sep-01	15.0	29.7	26.9%	39.0	34.1	37.6	30.8
Somerset (PA)	Oct-01	20.0	9.0	30.4%	43.9	37.0	43.0	35.2
Mill Run (PA)	Oct-01	20.0	15.0	33.5%	43.9	37.0	43.0	35.2
Rock River 1 (WY)	Oct-01	20.0	50.0	36.9%	35.5	29.9	35.1	28.8
Mountainview (CA)	Oct-01	10.0	66.6	38.3%	58.5	52.9	49.3	40.3
Llano Estacado (TX)	Nov-01	15.0	80.0	37.8%	24.7	21.5	25.5	20.9
Condon (OR)	Dec-01	20.0	49.8	25.6%	64.7	54.6	62.5	51.3
Stateline (OR)	Dec-01	25.0	297.0	34.1%	25.5	20.9	25.5	20.9
Cabazon (CA)	Aug-02	11.5	42.9	N/A	54.0	47.5	47.6	38.0
Whitewater (CA)	Aug-02	11.5	65.1	N/A	54.0	47.5	47.6	38.0
Shoshone (NV)	Dec-03	17.0	85.5	30.7%	50.8	41.8	48.4	37.8
Total			**1387.3**		***Capacity-Weighted Average:***		**38.4**	**32.0**

**The nominal prices are unadjusted for differences in commercial operation (i.e., on-line) dates.*

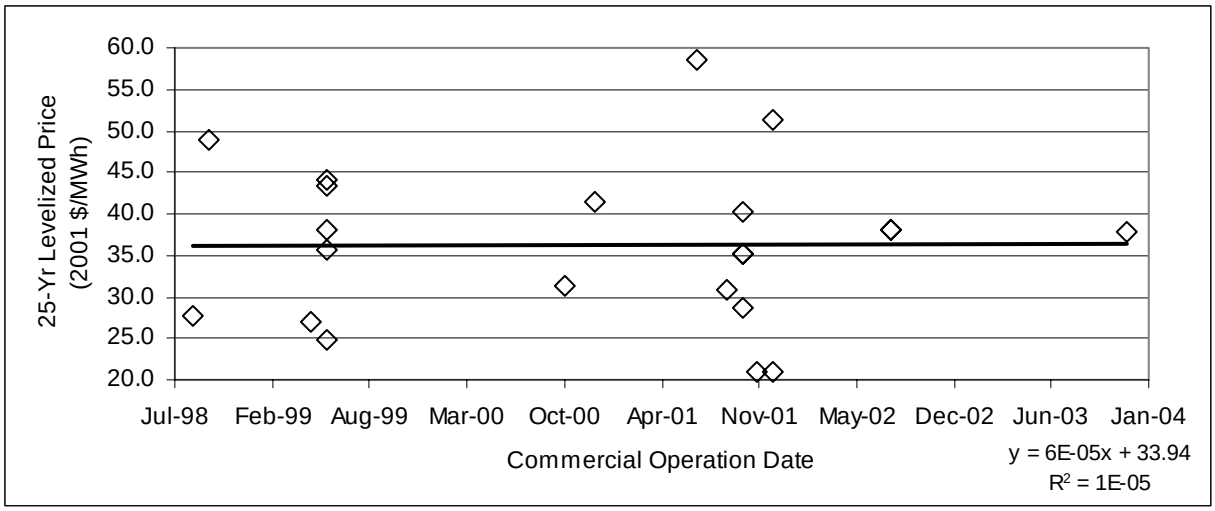
The *actual prices* shown in the table represent the levelized price over the duration of the contract term. To compare contract prices on a normalized basis, we also levelized the price stream of each contract over a 25-year period according to the following assumptions:

- Contracts with terms of less than 25 years earn a fixed $30/MWh (nominal) for their output once the contract term has expired.
- Contracts with options for extension (controlled by the buyer) will not be extended, and the project will simply earn a fixed $30/MWh (nominal) once the initial contract term has expired.
- The EIA's inflation projections contained in AEO 2003 (~2.5% average annual rate).
- 10% nominal discount rate.

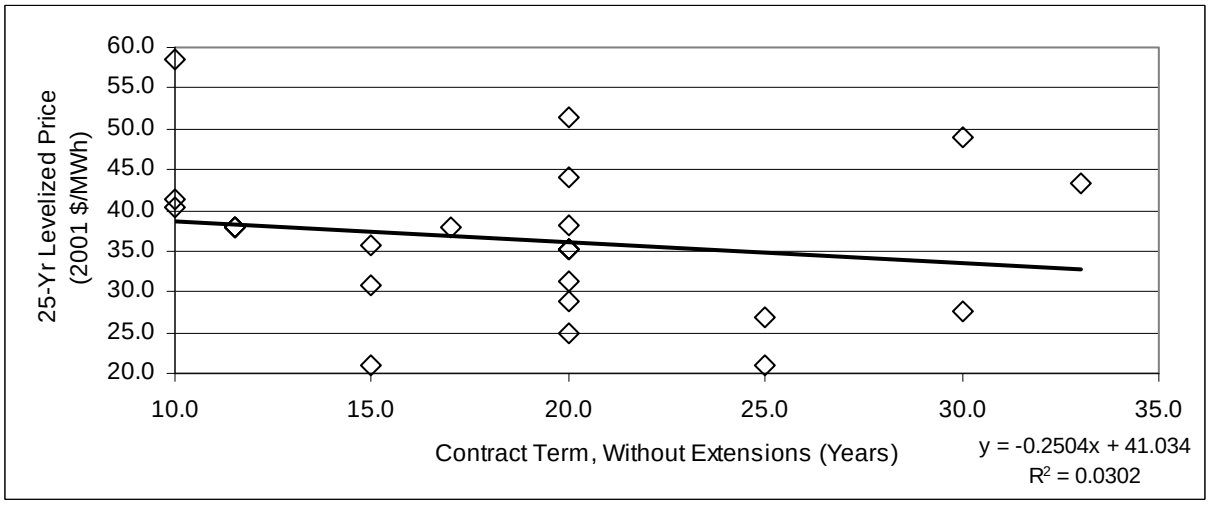
Results (nominal and real) are presented in the final two columns of Table 1.

The following graphs plot the 25-year real levelized price in 2001 $/MWh (i.e., the final column of the table) against other data from Table 1 (on-line date, contract term, capacity, and capacity factor). Best-fit equations and R^2 statistics are in the lower right-hand corner of each graph.

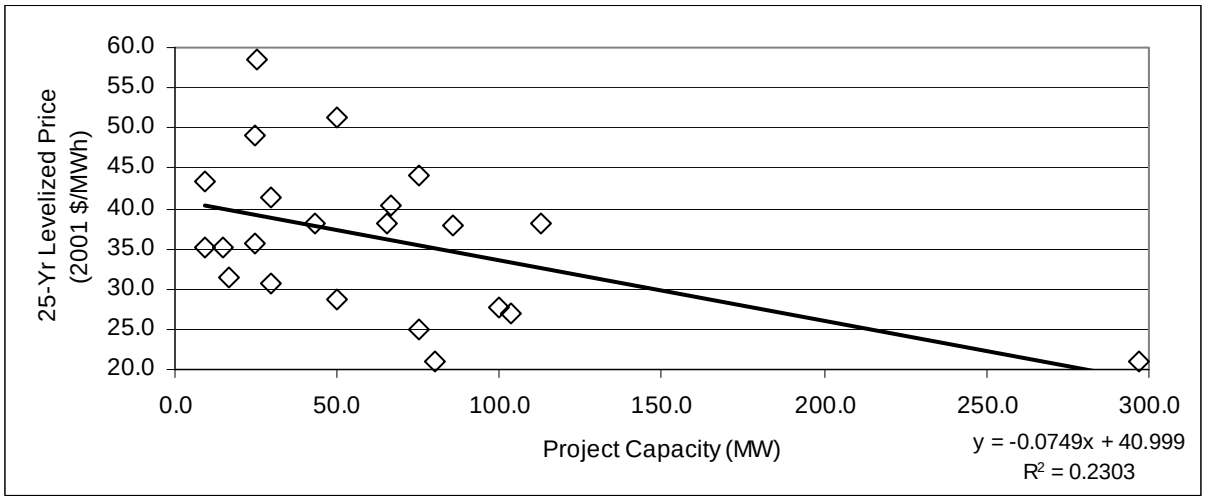
Commercial operation date appears to have virtually no statistical relationship to contract price in our 22-contract sample. Projects with earlier on-line dates do not have statistically significant differences in price to projects that come on-line later in the period. Given the limited range of dates represented in our sample (i.e., 1999-2004), perhaps this is to be expected.



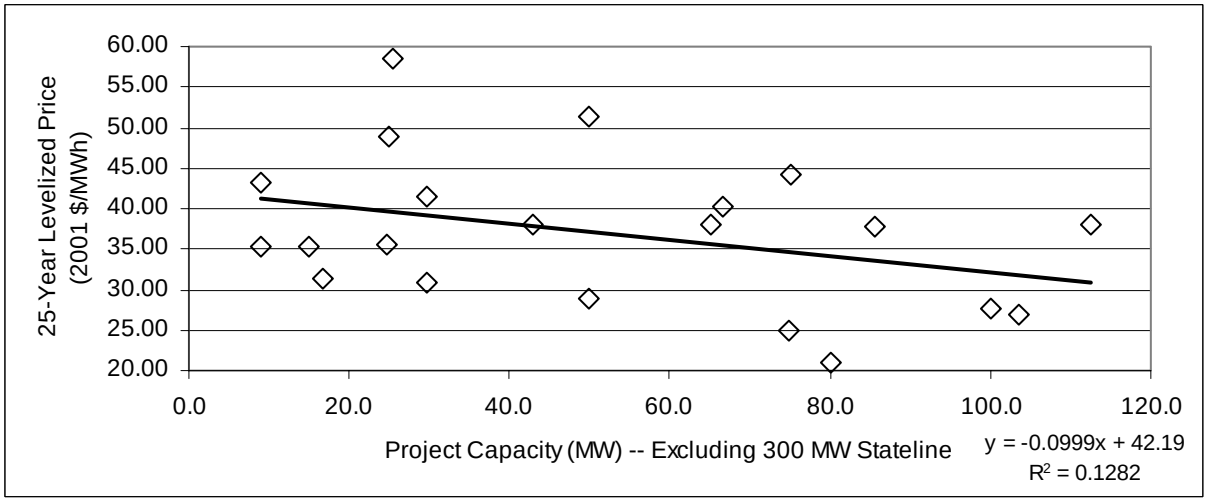
Contract term appears to exhibit some relationship to price (the best-fit line has a negative slope), but this relationship has little statistical significance.



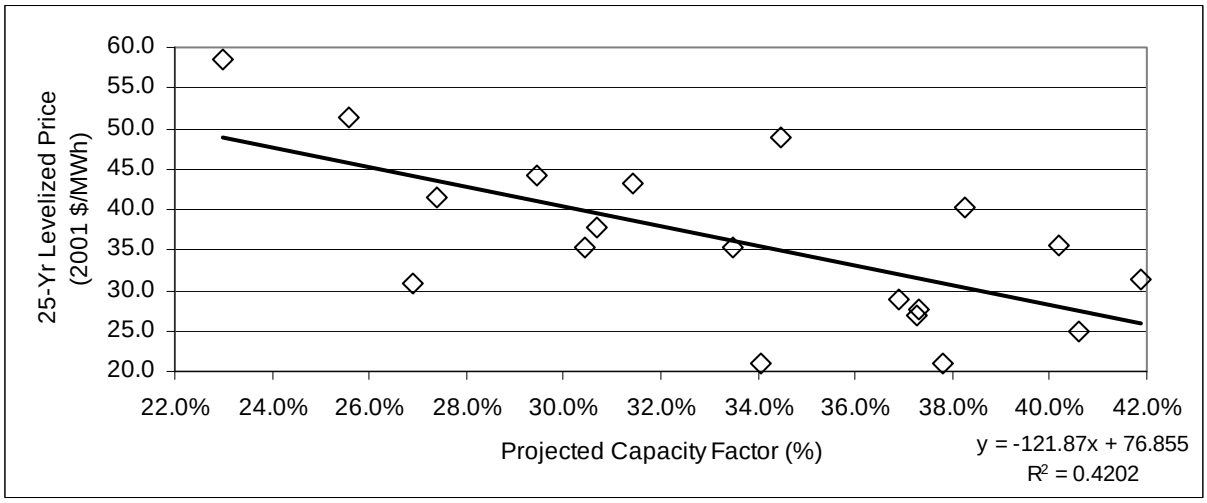
Project size appears to have a stronger relationship with contract price. This relationship is statistically significant at the 95% level (p = 0.024).



To see whether this relationship is being driven by the 300 MW Stateline project (an obvious outlier), we also plotted this data excluding Stateline. As shown in the next graph, the relationship continues to hold even without Stateline. Note, however, that the relationship is no longer as statistically significant as the relationship with Stateline included (p = 0.111).



Of the 4 variables examined, *capacity factor* has the most statistically significant impact on contract price (p = 0.003).



Running a simple multiple linear regression with the *25-year real levelized price* as the dependent variable and *on-line date*, *capacity*, *capacity factor*, and *contract term* as independent variables yielded an adjusted $R^2 = 0.51$ and the parameter estimates in Table 2.

Table 2. Parameter Estimates from Multiple Regression

	Estimate	Standard Error	t Ratio	p Value
Intercept	240.614	156.494	1.538	0.146
On-line Date	0.000	0.000	-1.054	0.310
Capacity	-0.056	0.028	-1.984	0.067
Capacity Factor	-123.494	33.904	-3.642	0.003
Contract Term	-0.104	0.318	-0.326	0.749

As shown, *on-line date* and *contract term* are not statistically significant. This confirms our earlier finding: neither the on-line date of the project nor the contract term appears to uniquely influence contract prices in our sample. The size or c*apacity* of the project does influence contract prices in a statistically significant way. *Capacity factor*, meanwhile, is highly significant and dominates the results. These findings are consistent with those from the simple regressions above.

Conclusion

Our sample of 22 power purchase agreements with wind projects reveals a wide range of contract prices. Our brief analysis shows that this range is not explained by the date that a project begins commercial operations or the length of the PPA, though project size does appear to have some bearing on contract price. The most substantial driver, however, appears to be capacity factor.